PART I

Background Information

HISTORY OF THE CHLORIDE CONTROL STUDIES

The Red River Basin covers nearly 94,000 square miles in the five state area of New Mexico, Oklahoma, Texas, Arkansas, and Louisiana in the south-central United States. Runoff from this area represents a major national and regional water resource. However, this resource is unsuitable for most beneficial uses because of poor water quality. The primary pollutants are chloride salts, principally from natural sources. The effects of this pollution are widespread, severely limiting the use of the stream for municipal, industrial, and agricultural water supply. Studies to control the natural salt pollution were begun in 1957 when Congress directed the U.S. Public Health Service to locate the major sources. Ten major source areas were identified.

PRIOR REPORTS AND STUDIES

In 1959, Congress directed the Corps of Engineers to determine the costs and benefits of alternative control plans. The U.S. Army Corps of Engineers has developed a plan to control the natural salt pollution at the source areas. The authorized Chloride Control project will eliminate 69 percent of the natural chloride pollution resulting in substantial improvements in the total dissolved solids and chloride concentrations of the basin's waters.

Experimental work at Estelline Springs, Texas (Area V), in the Upper Red River Basin, was authorized in 1962, and an effective control plan was completed two years later. A survey report completed in 1966 recommended Chloride Control plans at the salt sources on the Wichita River portion (Part I) which include Areas VII, VIII, and X. Part I was authorized by Congress in 1966, and preconstruction planning was initiated in 1968. The remaining areas in the Red River Basin (Part II) were the subject of a second survey report completed in 1966 which recommended Chloride Control plans at five of the remaining six salt source areas. Area XI was not recommended for further studies. Part II was authorized for construction in 1970. Detailed studies for the three areas in the Wichita River Basin were completed in 1972. In 1974, the Water Resources Development Act provided special authorization to construct control measures at Area VIII on the Wichita River. Construction at Area VIII was begun in 1977.

In 1976, General Design Memorandum No. 25 was submitted recommending control measures for the Wichita and Red River areas. Area XV and the North Pease River portion of Area IX were not considered economically feasible at that time and were recommended for future consideration. In 1978, the Chief of Engineers requested an economic reanalysis of the entire Red River Chloride Control plan to include a significantly more detailed benefit analysis. The economic reanalysis was completed in 1980. Subsequent engineering and design studies have continued to further refine the project plan. The further refinement of the project was made in General Design Memorandum Nos. 26 and 27 completed in 1978 and 1982, respectively.

AUTHORIZING LAWS

The Chief of Engineers recommended Part I of the Arkansas-Red River Basin Water Quality Control Study for Areas VII, VIII, and X, Wichita River, Red River Basin, in Senate document No. 110, 89th Congress, 2nd session. The

Flood Control Act of 1966 (PL 89-789, November 7, 1966) incorporated Senate Document No. 110 by reference and authorized Part I. Actual construction was not to be initiated until Part II was authorized. The Flood Control Act of 1970 (PL 91-611, 31 December 1970) amended the 1966 Act and authorized Part II of the study for Areas VI, IX, XIII, XIV, and XV in the Red River Basin. Construction was not to be initiated until approved by the Secretary of the Army and the President. Part II of the study was recommended by the Chief of Engineers in his report dated May 6, 1970. The Water Resource Development Act of 1974 (PL 93-251, March 7, 1974), specifically authorized construction of Area VIII without the approval of the Secretary of the Army and the President. The Water Resources Development Act of 1976 (PL 94-587, October 22, 1976) amended the Flood Control Act of 1970 thus eliminating the required approval of the President.

The Water Resources Development Act of 1986 (PL 99-662) amended the previous laws and authorized construction of the remaining elements of the Red River Basin project, subject to a report of favorable findings by a review Panel regarding the effectiveness of the operation of Area VIII.

SOURCES AND PROBLEMS

SOURCE OF CONTAMINATION

During the Permian Period, about 230 million years ago, much of the Texas panhandle, southeastern New Mexico, western Oklahoma, and southern Kansas was covered by a shallow inland sea. Over time evaporation precipitated salts in the sea water leaving thick deposits of halite which are currently present in geologic formation underlying the area. Natural chlorides from ten major salt source areas in the Red River Basin contribute about two-thirds of the average daily load of 3,300 tons/day of chlorides entering the river. The process by which this occurs is as follows: fresh groundwater migrates downward and laterally to the salt beds, which are 15 to 120 meters below the surface, dissolving the salt to produce brine. The brine is then forced laterally and upward by hydrostatic pressure through aquifers or through joints, fractures, and solution channels until emitted at the surface. In some areas the brine is emitted as a flowing spring. In others, it is emitted from seeps along the stream bed and becomes part of the surface waters. Contaminants further degrade the surface flows when capillary action causes surface encrustations (salt flats). The locations of the ten major salt sources in the Red River Basin are shown in Figure 1. Loads from these areas vary from 48 tons of chloride per day at Area X in Texas to over 510 tons of chlorides per day at Area VI in Oklahoma (see Table 2).

EFFECTS OF CONTAMINATION

Natural pollution renders the Red River generally unsuitable as a dependable source of irrigation and municipal and industrial water supply. In the western part of the basin, agricultural potential is severely restricted since thousands of acres of irrigable land cannot be irrigated from the river, or can only be irrigated to a limited extent. Because of high salinity, municipalities and industries in the benefitted areas (Arkansas, Louisiana, Oklahoma, and Texas) will suffer damages to pipes, equipment, and household appliances and possibly suffer adverse health affects from use of untreated water, pay the high cost of elaborate treatment

TABLE 2

LOCATION AND CHLORIDE LOADS OF RED RIVER SALT SOURCE AREAS

Area	Location	Receiving Stream	Chloride Load (ton/day)
V	Hall County, TX	Prairie Dog Town Fork of Red River	300[a]
VI	Harmon County, OK	Elm Fork of North Fork Red River	510
VII	Cottle County, TX	North Fork of Wichita River	186
VIII	King County, TX	South Wichita River	195[b]
IX	Cottle County, TX	North and Middle Pease River	342
X	King County, TX	Middle Fork of Wichita River	48
XI	Briscoe & Armstrong	Prairie Dog Town Fork of Red River	220
XIII	Childress County, TX	Jonah Creek - Tributary of Prairie Dog Town Fork of Red River	420
XIV	Childress County, TX	Salt Creek - Tributary of Prairie Dog Town Fork of Red River	150
XV	Hall County, TX	Little Red River - Tributary of Prairie Dog Town Fork of Red River	120

[a]Ring dike operational since 1964.
[b]Sum of calculated loads at Bateman and Ross Ranch.

processes to reduce the salinity, or obtain fresher supply sources from greater distances to fulfill their demands for water. In some cases, the water can and is being used by withdrawing water during high flows when the chloride concentrations are diluted. This manner of usage requires large offstream storage to supply needs during prolonged low-flow periods. The water can also be used for municipal and industrial purposes by diverting flows and mixing with fresher water sources. However, this method likewise limits the quantities which can be used because mixing ratios must be carefully monitored to maintain acceptable and consistent water quality.

The large quantities of water in the Red River that could be available for water supply have not been fully used because of the natural salt pollution. If this salinity problem were reduced or eliminated, much greater use could be made of existing water supplies, and the need to construct additional reservoirs and to mine limited ground water supplies would be diminished.

SELECTED PLAN

The selected plan for the salt emission areas authorized for construction is presented in this section. An existing ring dike at Area V is to be operated as constructed. No technically feasible control plan was developed for Area XI. The control plans for Area XV and the North Pease River portion of Area IX, although technically feasible, were not economically justified and were recommended for future consideration. The selected plan includes Areas VI, VII, VIII, IX (Middle Pease River only), X, XIII, and XIV and three brine lakes (Salt Creek, Crowell, and Truscott). The overall plan is illustrated in Figure 2. Descriptions of the various elements of the Chloride Control project follow.

AREA V

Estelline Springs is approximately 1 mile east of Estelline, Texas, near the Hall-Childress County line (Figure 2). The spring is in the flood plain of the Prairie Dog Town Fork of the Red River at about river mile 1,073. Salt water in this area is brought to the surface through the one large spring and several small seeps. Under natural conditions the average rate is about 4 cubic feet per second (cfs) and contributes 300 tons of chlorides per day to Mountain Creek, a tributary of the Prairie Dog Town Fork. An experimental project was constructed at the spring to test the application of backhead as a means of suppressing individual brine springs. The structure around the springs is a circular earthen dike 9 feet high and 340 feet in diameter with an impervious core to firm rock. In January 1964, the spring flow was completely suppressed by an average 5 feet of backhead. The spring has since maintained a reasonably constant level and the ring dike contains about 80 percent of the total chloride load emitted from Area V. The experimental status of the structure has been changed to an operational status as a permanent control installation.

AREA VI

The Area VI plan includes brine collection on the Elm Fork of the Red River and disposal in the Salt Creek Brine Lake (Figure 2). In the plan, collection of brine on the Elm Fork is accomplished by construction of a 115-acre brine detention reservoir. A dam across the Elm Fork encloses the upstream and downstream limits of the emission area, the present Elm Fork channel and adjacent flood plain through the south bank emission zone. Diversion of the Elm Fork at a point above the detention site is accomplished by a 200-foot bottom width channel excavated in the flood plain north of the present Elm Fork channel. From the collection facilities, the brine is pumped to the Salt Creek Brine Lake through a 4-mile pipeline. The Salt Creek Brine Lake dam is a 4,500-foot earthen embankment. The lake has a surface area of 735 acres at the top of the brine storage pool. The total controlled storage is 33,430 acre-feet for control of the 100-year frequency storm and for 100 years accumulation of brine and sediment.

AREA VII

In the plan for Area VII, brine is collected on the North Fork of the Wichita River by a low flow dam at river mile 213 and stored in Crowell Brine Lake (Figure 2). The low flow dam has a five-foot high deflatable weir that extends across the existing stream channel. The weir impounds a minimum pool to facilitate pumping and deflates to eliminate a channel restriction during high flow periods. The chloride concentration during flood conditions is too low to justify collection. Pumps and pipeline are used to transport the brine to Crowell Brine Lake. Crowell Brine Lake is located in Ford County at mile 1.6 on Canal Creek, a Pease River tributary. This lake is the disposal facility for Area VII. Storage for brine from Area IX is also be provided. The brine storage dam consists of an earthen embankment and the lake has a surface area of 3,820 acres at the top of the brine storage pool and 4,190 acres at the top of the flood control pool. The total controlled storage is 191,000 acre-feet for control of the 100-year frequency storm and 100-year accumulation of brine pumped from Areas VII and IX, and for future development at Areas IX and XV.

AREA VIII

The plan for Area VIII includes two low flow collection dams which are required on the South Fork of the Wichita River to collect brine which is be pumped to Truscott Brine Lake (Figure 2). One dam, already completed at river mile 74.9, consists of a 5-foot high deflatable weir. The weir across the existing stream channel impounds a pool to facilitate pumping and deflates during periods of high stream flow. The brine is transported by a pumping facility (Bateman Pump Station) and pipeline to Truscott Brine Lake. If needed, the second brine collection structure will be located at river mile 61.5. The need will be determined after operation of the upstream collection facility. Pumping facilities (Ross Pump Station) will be built to pump the brine through a pipeline to Truscott Brine Lake for disposal. Truscott Brine Lake is at mile 3.6 on Bluff Creek, a south bank tributary of the North Fork of the Wichita River. The earthfill embankment has a maximum height of 100 feet above the streambed and a total length of about 14,800 feet. The lake has a surface area of 2,980 acres at the top of the brine storage pool and 3,090 acres at the top of the flood control pool. The total controlled storage is 116,200 acre-feet for control of the 100-year frequency storm and 100 years accumulation of brine and sediment. Truscott Brine Lake is designed to contain brine flows from collection facilities at Areas VIII and X.

AREA IX

The Area IX plan consists of a surface collection system and a pipeline system, with disposal at Crowell Brine Lake (Figure 2). The plan is to collect flows up to a maximum of 20 cfs from the Middle Pease River, which contains 190 tons/day of chlorides. The collection structure consists of a reinforced concrete structure with a fiberglass grate. The water is diverted over the collection structure by an overflow and training dike. A 200-acre-foot storage pond is provided to minimize pipeline size. The proposed storage pond has an average area of 49 acres and a maximum depth of 7-feet. The collection system for the North Pease is recommended for future consideration.

AREA X

The Area X plan consists of a low flow dam which collects brine on the Middle Fork of the Wichita River at mile 20.5 (Figure 2). The low flow dam is similar to that described for Area VIII. The brine is pumped to to Truscott Brine Lake (discussed in detail with Area VIII).

AREAS XIII AND XIV

The plan for Areas XIII and XIV consists of a subsurface collection and pipeline system, water treatment, and subsurface disposal (Figure 2). Area XIII has three large-diameter wells and Area XIV has two large-diameter wells drilled into the brine aquifer. The wells are about 25 feet deep. The raw brines from the collection wells are transported through pipelines to a treatment plant and then to injection wells for disposal. The injection wells are drilled into the Ellenburger formation about 5,800 feet below the surface. Five injection wells are required for both Areas XIII and XIV.

AREA XV

The Chloride Control plan for Area XV was not economically feasible and is recommended for future development. The collection facility considered consisted of a subsurface cutoff wall combined with a shallow well system. Three separate collection areas are used: Bluff Creek, Lost Mule Creek, and the main stem of the Little Red River. The subsurface cutoff walls are located at the mouths of Bluff and Lost Mule Creeks and upstream from the Highway 70 bridge. The system design is similar to that discussed for Area VI. The shallow well system is located upstream from the subsurface cutoff wall and is of the same design as proposed for Area IX. Brine from both the subsurface cutoff and the shallow well system would be pumped through a pipeline system for that area to Crowell Brine Lake for disposal. Crowell Brine Lake was discussed in the plan of improvement for Area VII.

PLAN EFFECTIVENESS

The objective of the Chloride Control project is to provide the most practical means of improving the quality of water in the Red River Basin for beneficial uses. It is estimated that the selected plan will be very effective in accomplishing the objective. The natural chloride loadings and the expected effectiveness are presented in Table 3 for each salt source area. Table 3 is quoted from "Supplemental Data to Arkansas - Red Basin Chloride Control, Red River Basin, Design Memorandum No. 25, General Design, Phase I - Plan Formulation," Vol. 1, Department of the Army, Tulsa District, Corps of Engineers, Tulsa, Oklahoma, November 1980; page II-16.

TABLE 3

ANTICIPATED CHLORIDE CONTROL PLAN ACCOMPLISHMENTS ACCORDING TO DESIGN

Salt Source Area	Estimated Average Natural Chloride Load (tons/day)	Estimated Chlorides Controlled (tons/day)	Estimated Chlorides Controlled (Percent)
V	300	240	80[a]
VI	510	420	82
VII	186	157	84
VIII	195[b]	165	85
IX	342	190	60
X	48	40	84
XI	220	-	-
XIII	420	370	88
XIV	150	130	87
XV	120	-	-
Total Identified Natural Source	2,491	1,712	69

[a]Ring dike operational since January 1964
[b]Sum of calculated loads at Bateman and Ross Ranch.

Source: Design Memorandum No. 25, Vol. 1, Department of the Army, Tulsa District, Corps of Engineers, Tulsa, Oklahoma, November, 1980; Page II-16

CURRENT STATUS

Preconstruction planning for the Red River Chloride Control Project is complete. Plans and specifications have been completed for portions of Areas VII and X which would allow construction to be initiated when funds become available. Plans could be completed quickly for a portion of Area VI so that construction could also be initiated when funds become available.

As previously stated, Area VIII and Truscott Brine Lake were authorized for construction in March 1974. Construction of the Bateman Pump Station and Truscott Brine Lake was initiated in 1976 and the project was essentially complete and declared operational in May 1987.

EVALUATION PANEL HISTORY

In accordance with PL 99-662 an evaluation study Panel was established to evaluate the effectiveness of operation of Area VIII of the Red River Chloride Control Project. The Panel consists of:

Dr. Jack Keller (Panel Chairman)
Professor, Department of Agricultural and Irrigation Engineering
Utah State University
Logan, Utah

Mr. Jack Rawson (Panel Vice-Chairman)
Associate District Chief,
Texas District, Water Resources Division,
U.S. Geological Survey
Austin, Texas

Dr. Herbert Grubb
Director of Planning
Texas Water Development Board
Austin, Texas

Mr. Jackson H. Kramer
State/Federal Relations Coordinator
Texas Water Commission
Austin, Texas

Mr. Glenn Sullivan
Secretary of Natural Resources
State of Oklahoma
Oklahoma City, Oklahoma

The first meeting of the evaluation Panel was held in Wichita Falls, Texas, on 23 October 1987. The purposes of this meeting were to officially convene the Panel, to brief the Panel on the background and objectives of the entire project, and update members on the status of Area VIII and the data collection program being conducted by the United States Geological Survey (USGS). This was accomplished by a series of presentations by the Tulsa District, U.S. Army Corps of Engineers, and the USGS, and aerial reconnaissance and field visit to Bateman Pump Station and Truscott Brine Lake. The following quotations from the minutes express the important decisions of the meeting:

"4. ...It was generally concluded upon by all present that the data currently being collected at the Bateman gages (located upstream and downstream of the Bateman Pump Station) and the Benjamin gage (located on the South Fork of the Wichita River, approximately 50 river miles downstream of Bateman) were all that could be effectively used and that this data should be sufficient to allow proper evaluation of the effects of Area VIII operation. This data is to be used to show the reduction of chlorides in tons/day and mg/l at both the Bateman and Benjamin gages."

The Panel requested the Corps to assemble the following information for the follow-up meeting:

"a. A correlation of the data collected at the Bateman and Benjamin gages to allow:

(1) Synthetic development of stream flows and loads for periods when records are not available.

(2) Determination of the predictability of stream flow and loads.

b. The expectations and assumptions made by the Corps of the response of the South Fork of the Wichita River at the Benjamin gage in terms of chloride loads and concentrations used in cleanup evaluations and benefit analysis.

c. Physical sample data for the alluvial and stream flows for the South Fork and its tributaries above the Benjamin gage.

d. Any alluvial geotechnical data available in the reach between the Bateman and Benjamin gages."

At the November 30 meeting data requested were assembled by the Corps and reviewed by the Panel and the following decisions, as quoted from the minutes, were reached.

"11. Discussion followed on the probability and mechanism for flushing out the brines stored in the alluvial pore water between Bateman and Benjamin. It was concluded that due to the nature of the fine-grained alluvium, unless some major event occurred which could cause a mixing of pore water for the full depth of the alluvium (on the average of 20 feet), these brines would remain in place for the entire life of the project without causing any detrimental effects. The Panel agreed that no additional geotechnical analysis need be made.

"12. Mr. Bob Brown then made a presentation concerning project benefits as presented in the November 1980 report and the economists expectations concerning the water quality passing the Benjamin gage. The Panel agreed and restated their positions from the initial meeting that it would be outside the charge and authority of the evaluation Panel to attempt a reanalysis of the benefits.

"13. The Panel recognized that the period of (May - October 1987) for the operation of Bateman Pump Station represents an extreme wet period. This produced a higher concentration-duration curve than the long term average concentration-duration curve projected in the November 1980 report for the modified conditions. Therefore, the Panel recommended that collection be continued in order to make a better comparison between actual modified conditions and those projected in the November 1980 report.

"14. After considerable discussion concerning the data presented, the Panel decided that they would like to see some comparisons made using mass curves and the data from the historical period of record, the forecast collectable flows and loads, and the actual measurements from the period of operation. Using the historical data available for the Benjamin gage, the Corps was instructed to develop a single mass curve, plotting volume (in ac-ft) versus time. Then using the same type of curve for the period of time representing one year before pumping (May 1986 through April 1987) to the present time, the Corps is to find a "best fit" match with the historical mass curve to designate a period of time that will be used to judge the results at the Benjamin gage.

"15. Mass curves, plotting load of chlorides (tons) versus time will be developed and compared for the historical data and the data from one year before pumping to the present. The deviation of these two curves should provide a reasonable indication of the amount of tonnage removed by the operation of the Bateman Pump Station. An example of these curves is attached.

"16. The Panel also requested that another set of curves be developed. These curves will be in the form of the "scatter diagrams" presented by Mr. Fly. The period of record from 1971 through 1976 is representative of the entire historical period of record available for the Benjamin gage, and there is also data for the Bateman gage. This historical data will then be used to develop a forecast diagram (assuming the Bateman pumping station was in operation) to be compared with data collected during the actual (current) period of operation. An example of such a curve is attached."

At the meeting of February 18, the following decisions (quoted from the minutes) follows:

"5. Dr. Keller inquired as to the time the Corps expects benefits to start being realized from the project and asked what our time scale was for the system to stabilize, as included in the 1980 report.

Mr. Jim Sullivan indicated that no benefits were to be counted until all proposed elements of the project became operational. In the 1980 report, the economic analysis was based on starting the benefit flow upon the completion of the entire works in 1990. At this time, the start of construction of the remaining project elements is indeterminate until Congress appropriates construction funding for that purpose. With continued funding, construction of the remaining project could be complete in about 10 years.

"6. Dr. Keller then opened for discussion the Memorandum for Record of the 30 November 1987 - 1 December 1987 meeting of the Panel. It was determined that Item 11 on page 3 of the Memorandum for Record dated 2 December 1988 should be revised to say, "We agree, in a sense, that no additional geotechnical analysis is needed. We feel that in view of the data, that there may be considerable brine coming from the leachate between Bateman and Benjamin." The second sentence of paragraph 13 should be changed to read, "This produced a concentration-duration curve which is not comparable to the long term average concentration-duration curve projected in the November 1980 report for the modified conditions...

"7. A general discussion of the data presented, followed. The attempt to compare the recent data at Bateman and Benjamin with the historical data at these gages over the period 1971-1976 did not appear to provide better insight into understanding the effects of diversion at the Bateman pump station. There were, however, windows of time in the prediversion data recorded for Bateman and Benjamin that seemed to compare with Data from both stations after Area VIII was placed in operation in May 1987. There were two periods of a rather high flush of water and taper off of the flow in the period of time beginning October 1, 1986, on into the 1988 water year.

Mr. Fly was asked to provide a mass curve, scatter diagram and double mass curve analysis of the data during these periods of time by laying one plot on top of the other. A search should be made to find other periods of time that compare; these time periods should have similar flows at Bateman and Benjamin, and similar previous history and conditions both prior to and after beginning operation of the Bateman pump station. The mass curves, double mass curves and scatter diagrams desired for each window of time found comparable will contain four sets of points all starting from the same origin..."

During the course of the meetings it was decided by the evaluation Panel that a study of the data collected based on one year of operation of Bateman Pump Station would be sufficient to adequately assess the effectiveness of its operation.